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U. S. DEPARTMENT OF AGRICULTURE.

SILK SECTION.

BULLETIN No. 1.

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HOW TO RAISE
SILK-WORMS.

A BRIEF MANUAL OF INSTRUCTIONS,

ABRIDGED FROM

BULLETIN NO. 9 OF THE DIVISION OF ENTOMOLOGY.

BY

PHILIP WALKER,

CHIEF OF THE SILK SECTION.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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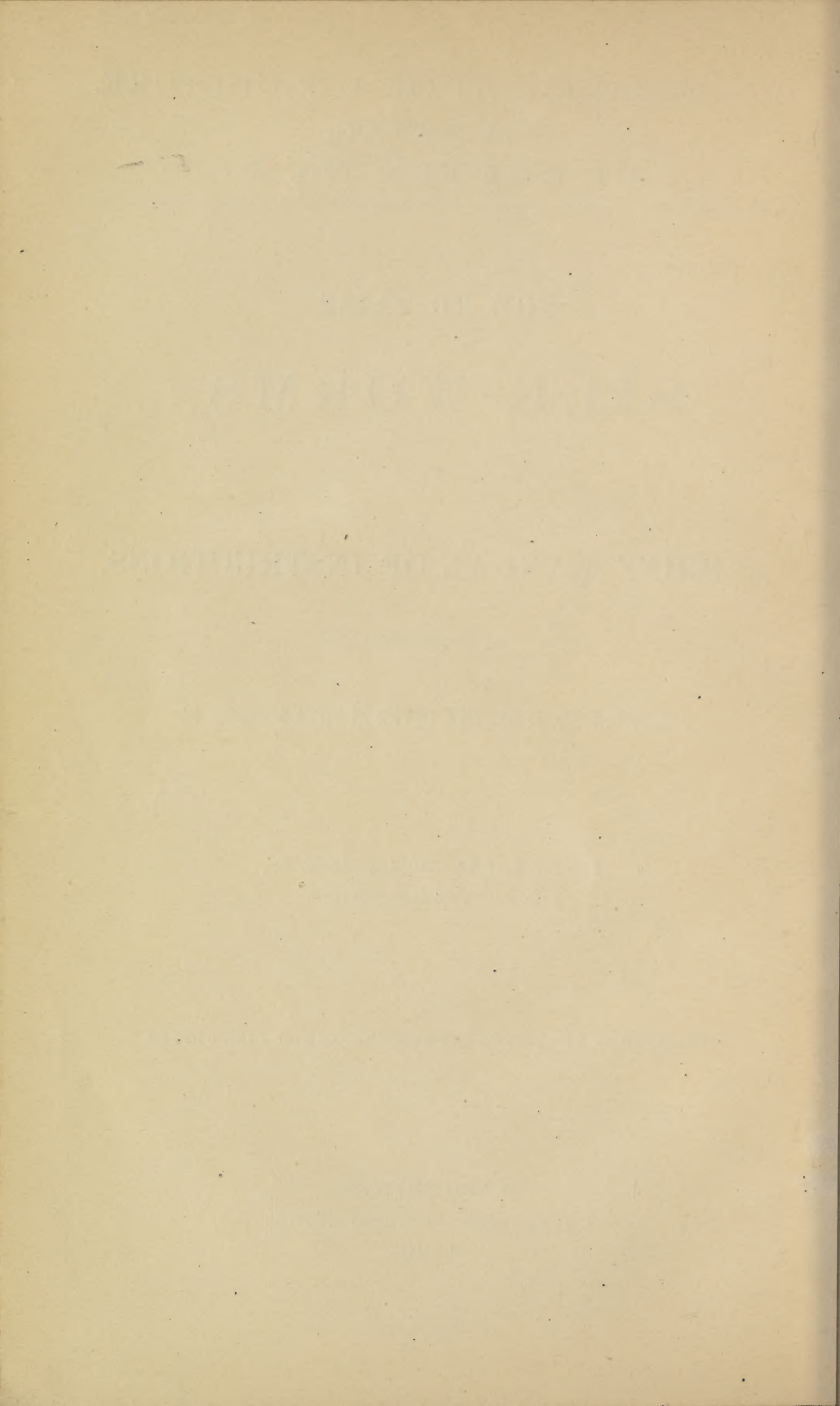
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
SILK SECTION,
January 27, 1890.

SIR: I have the honor to hand you herewith Bulletin No. 1, of this Section. It is essentially an abridgment of Bulletin No. 9, of the Division of Entomology, "The Mulberry Silk-Worm," and has been prepared in response to an unquestionable need for something of a preliminary nature which should not confuse beginners with the intricacies of the industry. It is for beginners only that this pamphlet is intended. For adepts something even more complete than the Entomologist's manual seems to me to be needed and I have such a work in hand.

Yours respectfully,

PHILIP WALKER,
Chief of the Silk Section.

Hon. J. M. RUSK,
Secretary of Agriculture.

HOW TO RAISE SILK-WORMS.

THE SILK-WORM AND ITS FOOD.

The ordinary silk of commerce is produced by the Chinese silk-worm (*Bombyx mori*), which in its natural state, as well as in most countries where the worm has been domesticated, feeds upon the leaf of the mulberry tree. The life of the insect may be divided into four epochs:—the egg, the worm, the chrysalis, and the moth. Early in the spring, at about the time the mulberry leaves bud out, the eggs hatch and from each issues a small worm about one-eighth of an inch long, covered with short black hairs. During the four or five weeks ensuing the silk-worm spends the greater portion of its time in feeding and, growing rapidly, attains a length of about three inches. Having reached its full size the worm ceases to eat and, finding some suitable place upon which to spin its cocoon, it commences to throw out a thread of silk which it forms into a peanut-shaped pod destined to protect the insect from the inclemency of the weather while it undergoes the transformations first into a chrysalis and then into a moth. About three weeks after the final formation of the cocoon both of these transformations will have been completed and the insect will issue in its adult form as a small whitish moth whose only function is to assist in the reproduction of its species. Silk raisers have generally only to do with that epoch which covers the time from the hatching of the egg to the completion of the cocoon. The production of the eggs and the reeling and the utilization of the cocoon for commercial purposes are parts of other industries a knowledge of which is not necessary to the persons who rear the worms and produce the cocoons.

This second epoch of the insect's life is divided into five different ages. These ages are separated by what are called molts, when the worm sheds its skin. This shedding of the skin is necessitated by the rapid increase in size of the insect, the original skin not possessing sufficient elasticity to allow for its growth, and it takes place four times with the ordinary races. The form and size of a full grown silk-worm are seen in Fig. 1.

It has been said that the silk-worm generally feeds upon the leaves of the mulberry tree. While there can be no doubt that the white mulberry tree, in some one of its different varieties, forms the most advantageous food which can be used for the silk-worm, it has been discovered that the leaves of other plants may be employed with a great degree of success. The most important of these plants and the only one known in the United States is the osage orange, which is used very

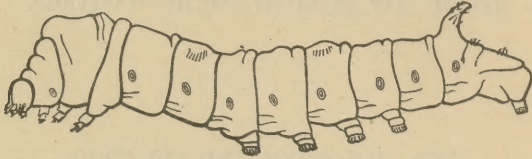


FIG. 1. Full grown silk-worm.

largely throughout certain portions of the country for the formation of hedges on our large farms. The osage orange plant is very thorny and its thorns injure the fingers of persons picking the leaves. When the leaves are gathered, however, the results obtained from feeding them to the worms are excellent. But, as economy in gathering the leaves is of great importance to the silk-grower, it would hardly be advisable to plant the osage orange with the express purpose of using it for rearing silk-worms.

The mulberry tree, on the other hand, while naturally bushy, may be so trained as to greatly facilitate the gathering of the leaves, and persons who intend to follow the culture of silk for any length of time are earnestly counseled to put in the necessary number of these plants. For those, however, who have osage orange at their disposal, and who are desirous, as are so many of the wives and daughters of the farmers of the United States, of experimenting with silk-worms, it is deemed advisable that they should use the leaves of the osage orange, only planting mulberry trees when, as I have said, they have decided to continue to follow the industry. After the second molt it will be better not to try to pick the osage leaves, but rather to cut off small twigs with the leaves on them and give them to the worms altogether. The succulent terminal leaves should not be fed after the third molt, as they are apt to breed disease, but should be cut off before the twigs are given to the worms. Persons not having enough mulberry, and intending to use osage orange in connection with it, had better save the mulberry for the last age, the most critical part of the worm's life.

IMPLEMENTS NECESSARY TO SILK RAISING.

For the small amount of worms raised during the first season a series of tables like those shown in Fig. 2 will be all that is necessary. These are made movable so that they can be taken down and put away when

not in use. The tables themselves can be covered either with slats or with wire netting such as is currently used in making chicken-coops. The latter can be obtained for about $1\frac{1}{2}$ cents per square foot in small quantities, or about 50 cents for each table. Such tables as have been

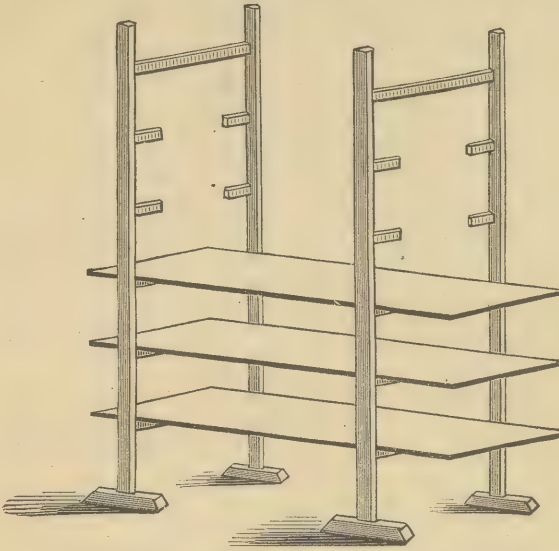


FIG. 2.—Standard for holding shelves.

mentioned are shown in Figs. 3 and 4. They should be 4 feet wide and 8 feet long. These tables should be covered with large sheets of un-

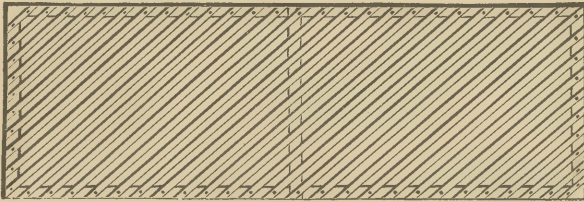


FIG. 3.—Frame covered with slats.

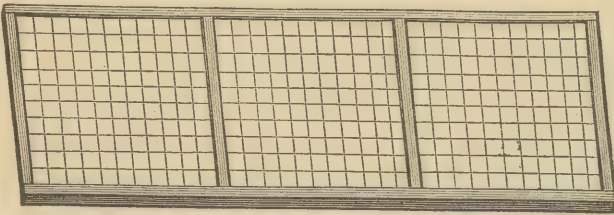


FIG. 4.—Wire-work shelf.

printed paper before the worms are placed upon them. All lumber used should be thoroughly seasoned and dry.

The litter left by the worms after feeding should be cleared away systematically, and, as far as possible, without handling the worms. This is done by means of perforated paper. During the second age this paper is perforated with holes about a quarter of an inch in diameter, the size of the sheets being, for convenience, about 12 by 18 inches. In the other ages the size of the holes increases in proportion to the size of the worms until for the last age they are about seven-eighths of an inch across. For the third, fourth, and fifth ages the paper is usually cut about 18 by 24 inches. To clean away the litter with this paper we must place it over the worms and sprinkle a copious supply of leaves upon it. The worms will come up through the holes in the paper to reach the new leaves, and, when the greater part of them have thus appeared, the paper, with the worms and leaves upon it, can be moved to another table. Such worms as remain on the litter can be transferred by repeating the operation. The litter left on the table can then be cleared away, and this should be done without raising any more

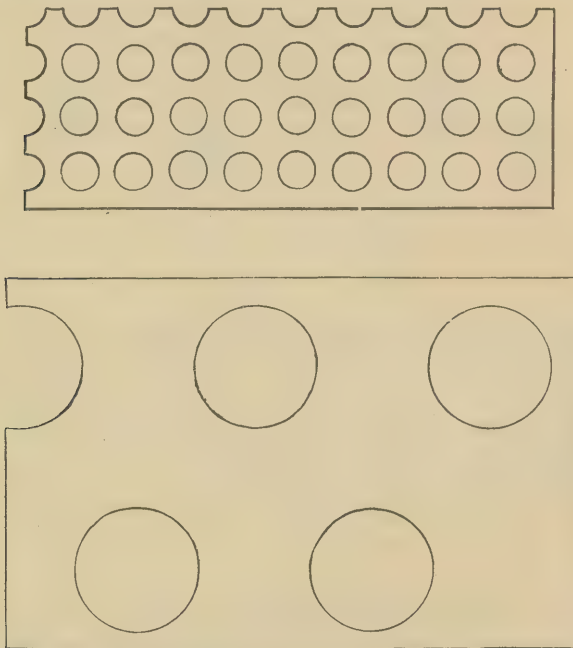


FIG. 5 —Perforated paper, showing the sizes of the perforations in the second and fourth ages.

dust than is necessary. Fig. 5 shows the perforations used during the second and fourth ages. A small piece of mosquito netting will suffice for these transfers at the birth of the worms and during the first age.

In gathering mulberry leaves for feeding the worms it will be found convenient to have a bag (Fig. 6), which may be attached like an apron around the waist. Two such bags can be made from an ordinary meal sack. In gathering osage orange leaves, however, the twigs and thorns

prevent their being easily shoved into the bag, and it is therefore better to use baskets.

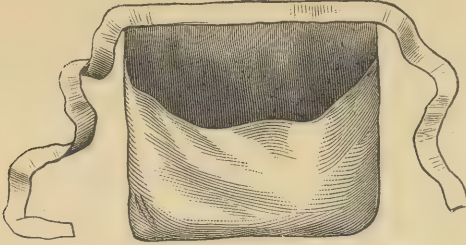


FIG. 6.—Bag for gathering mulberry leaves.

Every rearing-room should have a thermometer. One that will be good enough for the purpose can be purchased anywhere for half a dollar.

SILK-WORM EGGS: HOW TO WINTER AND HATCH THEM.

As has been said in the introduction this book is intended only for beginners in silk culture and some of the niceties of the industry are therefore intentionally neglected. Persons who have never reared silk-worms had better confine themselves to beginning with a small quantity. One-quarter of an ounce of eggs will be amply sufficient. But, while the quantity should be thus restricted, in order that the labor involved to inexperienced persons may not be so great as to prevent their observing closely all the changing phases of the silk-worm's life, it is a matter of the greatest importance that the eggs obtained should be of the best quality and of such a race that the cocoons raised may be easily marketed. Reliable dealers, whose reputation has been made by the superior quality of the eggs which they sell, are the only ones who should be dealt with. There are about 36,000 silk-worm eggs in an ounce; the quarter of an ounce recommended for beginners would, therefore, contain about 9,000.

These eggs may be obtained either in the spring, just before the time to begin the feeding, or early in the winter. In the latter case it is necessary that the eggs should be kept in such a manner that they be not injured or allowed to hatch until the leaves are ready to furnish food for the worms. There are but few requisites for the careful wintering of silk-worm eggs, the principal ones being that they should be kept cool and dry. For this purpose they may be placed in a cold, dry cellar, having preferably a northern exposure. It is better, however, for beginners to obtain their eggs in the spring, so that any danger which might arise from their hatching too early will be avoided. When the leaves begin to bud out the eggs should be brought into a warm room and left in the open air. They should not be exposed to direct sunlight, nor should they be too strongly subjected to the artificial heat of a stove. On the other hand they must not be placed in a room which becomes

cold during the night. If the eggs have been uniformly kept during the winter in a very cold place it will sometimes take from two to three weeks for them to hatch out. If, however, the degree of cold has not been so great they will hatch out in four or five days. In preparing the eggs for hatching it is better to spread them out very thinly on a sheet of clean paper, and prevent any vermin (such as roaches) from approaching them.

THE REARING OF THE WORMS.

When the silk-worm issues from the egg it is about one-eighth of an inch long and covered with black hairs. As the worm grows the hairs separate and the worm loses its dark color and becomes a rosy white.

When the first worms appear they should be covered with a small piece of mosquito netting upon which should be scattered a few leaves and buds. The netting with the worms and the leaves upon it can then be removed to the table upon which they are to be raised, this operation being continued until the majority of the worms have hatched. Under favorable circumstances this will take from three to four days. Silk-worms grow more rapidly when kept in a warm place than when in a cool one. It is well known, too, that a room is always warmer at the ceiling than at the floor. If, therefore, we place the worms first born on the lower table and those born later above them, giving the last an additional meal daily, it will be found that they will reach the first molt at about the same time.

Those which hatch out after the fourth day should always be thrown away, as they are undoubtedly weaker than the more advanced worms, and being consequently more subject to disease, may injure the first insects if raised with them. It is also sometimes advisable to throw away the more vigorous ones which are born on the first day. The reason given for this is that they will be so much ahead of the others as to interfere with the regularity of rearing. If, however, the instructions given above for equalizing the worms are followed this irregularity can be overcome and the size of the worms easily regulated later.

The worms are fed by scattering the leaves over them, care being taken to spread it evenly, so that all may be served alike. The worms during the first age should be fed about six light meals daily, the first early in the morning and the last late at night. During this and the next age the leaves should be chopped fine, as the worm eats only on the edge of the leaf, and it is important, in the interests of economy, to make as many of these edges as possible. In silk raising good and systematic habits are as important as elsewhere, and regularity in feeding is one of the most important of them. *Arrange the hours for feeding the worms so that about equal lengths of time shall separate the repasts, and then stick to them. Neglected silk-worms will never pay for the trouble they cause.*

The number of meals may be reduced to five during the second age

and to four during the last three. Retain the habit, however, of giving the first early in the morning and the last late at night.

It is only by experience that one can learn just what amount of food should be given to the worms. It may prove dangerous to feed them too copiously, as in the first ages the worms may become buried and lost in the litter, while later the massing of food in an attempt to satisfy their ravenous appetites may cause it to ferment and become productive of disease. In general they should be given all they will eat. The first meal after the fourth molt should, however, be light, as the worm at that time possesses a ravenous appetite and is apt to overeat itself. After this the meals should be very plentiful, as it is at this time that the worm fills its silk ducts, and if deprived of a full supply of food it will make a poor and feeble cocoon.

Great care should be taken to pick the leaves for the early morning meal the evening before, as when picked and fed with the dew upon them they are more apt to induce disease. Indeed, the rule should be laid down to *never feed wet or damp leaves to your worms*. In case the leaves must be picked during a rain they should be thoroughly dried with a cloth before being fed; on the approach of a storm it is always well to lay in a stock of food, which should be kept from heating by occasional stirring.

During the first and most delicate age the worm requires much care and watching. As the 5th or 6th day approaches signs of the first molt begin to be noticed. The worm begins to lose appetite, grows more shiny, and generally wanders to an unencumbered spot where it may shed its skin in quiet, and thus often gets hidden and buried under the superimposed leaves. The old skin begins to break away just above the head * making at first a dark-red triangular spot. The worm, in its pain, throws up the forward part of the body as shown in Fig. 7. When the molt is completed and the skin has been cast, the head appears a much lighter brown and somewhat swollen, and the legs seem drawn up and of little use. These symptoms soon disappear, however. When the first worms show these signs of molting, food should be given more sparingly and the meals should cease altogether as soon as the most forward worms awaken. When the time for the molt is near, say during the fourth day, it will be well to clear away the litter so that the worms may pass the crisis on a clean bed.

Some will undoubtedly undergo the shedding of the skin much more easily and quickly than others, but no food should be given to these forward individuals until nearly all have completed the molt. This serves to



FIG. 7. Silk worm during the fourth molt.

* Only the dark-brown shell-like muzzle constitutes the head.

keep the batch together, and the first ones will wait one or even two days without injury from want of food. It is, however, unnecessary to wait for all, as there will always be some few which cast their skins some time after their companions. These should either be set aside and kept separate or destroyed, as they are usually the most feeble and most inclined to disease; otherwise the batch will grow more and more irregular in their molting and the diseased worms will contaminate the healthy ones. It is really doubtful whether the silk raised from these weak individuals will pay for the trouble of rearing them separately and it will be better perhaps to destroy them. It is very important in the interest of that system whose value has been urged to keep each batch together and cause the worms to molt simultaneously. When this is done the work will be much simplified and much time economized.

As soon as the great majority have molted they should be covered with the perforated paper and fed. As they grow very rapidly after each molt the space which they occupy should be increased. This is readily done by removing the perforated paper when about half of the worms have risen and replacing it by an additional one. The space allotted to the worms should, of course, be increased proportionately with their growth.

The same precautions should be observed in the three succeeding molts as in this first one. The second and third castings of the skin take place with but little more difficulty than the first one, but the fourth is more laborious, and the worms not only take more time in undergoing it but more often perish in the act. At this molt it is better to give the more forward individuals a light feed as soon as they have completed the change, inasmuch as it is the last molt and but little is to be gained by the retardation, whereas, as has been said, it is important to feed them all that they will eat during this age. It would too be found inconvenient if all the worms were to arrive at the spinning period together, as extra assistance would be required to put in place the brush on which they spin their cocoons.

As regards the temperature of the rearing-room, great care should be taken to avoid all sudden changes from warm to cold or cold to warm. A temperature of 75 or 80 degrees will usually bring the worms to the spinning point in the course of thirty to thirty-five days after hatching, but the rapidity of development depends upon a variety of other causes, especially upon the quality of leaf. *If the rearing lasts more than thirty-five days from hatching to spinning, there can be no doubt that the worms have not been sufficiently fed, or that the rearing room has been too cold.* If it can be prevented the temperature should not be permitted to rise very much above 80 degrees. The air should be kept pure all of the time, and arrangements should be made to secure a good circulation without subjecting the worms to draughts. Great care should be taken to guard against the incursions of ants and other predaceous insects,

which would make sad havoc among the worms were they allowed an entrance, and all through the existence of the insect, from the egg to the moth, rats and mice are on the watch for a chance to get at them, and are perhaps to be feared most among the enemies of the silk-worm.

Too much can not be said in favor of giving the worms plenty of room. Every one should be free to move easily without incommoding its fellows. We should therefore allow the issue of an ounce of eggs during the first age from 10 square feet at the beginning to 30 square feet at the end of the age, daily extending the space occupied by them by spreading their food over a greater table surface. In the second age they should spread in the same manner so as to cover from 50 to 75 square feet, in the third from 100 to 160 square feet, and in the fourth from 200 to 320 square feet. Entering the last age, spread over 430 square feet of surface, they should gradually be extended until they occupy at the spinning period 640 square feet. It need hardly be said that when the worms have been decimated by disease the surface occupied by them need not be so extensive.

The litter of the worms should be cleared away in the manner described before and after each molt, and once each at about the middle of the third and fourth ages. While the worms are small the litter dries rapidly and may (though it should not) be left for several days on the table with impunity; but he who allows his tables to go uncleaned for too long a time during the two last ages will suffer in the disease and mortality of his worms just as they are reaching the spinning point.

The only disease which American silk raisers need fear at present is called flaccidity. It is caused by feeding the worms wet or damp leaves or perhaps by thunder storms and other bad weather. The worm attacked with it dies and turns brown and then black. The disease is caused by the food failing to digest and often kills off a whole lot of worms with surprising rapidity. There is no known way of stopping it once it attacks the worms, but it may be generally avoided by following carefully the instructions given above.

These, summed up, may be reduced to the following rules:

- (1) *Keep the worms of each lot uniform in size* so as to insure their molting simultaneously.
- (2) *Let them be systematically supplied with fresh food* except during the molting periods.
- (3) *Give the worms plenty of room* so that they may not crowd each other.
- (4) *Let there be plenty of fresh air and as uniform a temperature as possible, but have no draughts.*
- (5) *Use every means to insure cleanliness.*
- (6) *Never feed damp or wet leaves.*

The last four are particularly necessary during the fourth and fifth ages.

PREPARATIONS FOR SPINNING.

With eight or ten days of busy feeding, after the last molt, the worms will begin to lose appetite, shrink in size, become restless, and throw out threads of silk. The arches for the spinning of the cocoons must now be prepared. These can be made of *dry* twigs 2 or 3 feet long, set up upon the shelves over the worms and made to interlock in the form shown in Fig. 8. The feet of each arch should be only about a foot apart.

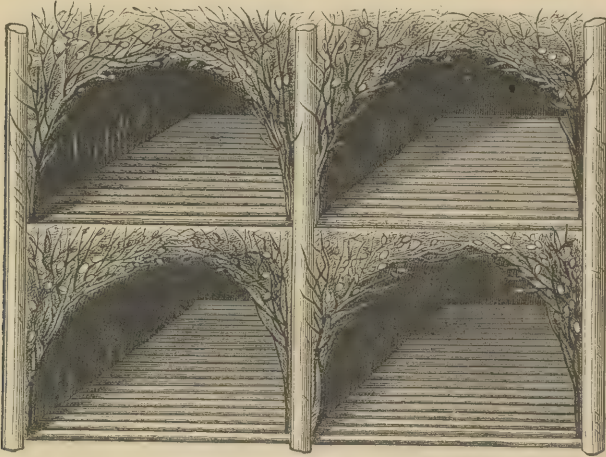


FIG. 8.—Method of constructing arches upon which the cocoons are spun.

The temperature of the room should now be kept above 80 degrees as the silk does not flow so freely in a cool atmosphere. The worms will one by one mount into the branches and commence to spin their cocoons.



FIG 9.—Cocoon.

They will not all, however, mount at the same time, and those which are more tardy should be fed often, but in small quantities at a time, in order to economize the leaves, as almost every moment some few

will quit and go up into the arches. There will always be a few which fail altogether to mount and prefer to spin on the tables.

As the worms begin to spin they should be carefully watched to guard against two or three of them making what is called a double or treble cocoon, which would be unfit for reeling purposes. Whenever one worm is about to spin too near another it should be carefully removed to another part of the arch. In two or three days the spinning will have been completed, and in six or seven the chrysalis will have been formed. Fig. 9 shows a medium sized fine cocoon spun by a worm of a yellow annual race.

PREPARING THE COCOONS FOR MARKET.

Eight days from that on which the spinning fairly commenced it will be time to gather the cocoons. The arches should be carefully taken apart and the spotted or stained cocoons first removed and laid aside. Care should be taken not to stain the clean cocoons with the black fluids of such worms as may have died and become putrid, for there are always a few of these in every cocoonery. Too much care can not be taken to remove the soft or imperfect cocoons as, if mixed with the firm ones, they would be crushed and soil the latter with their contents. The floss surrounding the cocoons should be thoroughly removed before stifling.

In most silk-producing countries the persons who raise the cocoons sell them to the reeling establishments before it becomes necessary to kill the chrysalis, as these establishments have better facilities for this work than are to be found in private families. If, however, the reeling is done by the raiser, or some time must elapse before the cocoons can be sent to a reeling establishment, some means must be used to stifle them before they are injured for reeling purposes by the egress of the moth. This can best be done by steaming them.

The following apparatus has been used at the Department and found satisfactory: It consists of a tin reservoir (Fig. 10) about one-third filled with water. Slightly above the surface of the water is a movable perforated partition B, intended to prevent spattering during ebullition. The upper portion contains a perforated pan for holding the cocoons while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus over boiling water for twenty minutes. It will be seen, too, that much the same apparatus may be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should be subjected only to the action of steam. The apparatus is 12 inches in diameter and 13 inches deep and will stifle from 3 to 4 pounds of cocoons at a time.

Cocoons submitted to this process should be thoroughly dried to prevent their molding. This takes about three months. They should

be spread out in layers not more than 4 or 5 inches deep and should be stirred every few days at first and less frequently later. They should be guarded from rats and mice which eat through the cocoon and devour the chrysalis. When thoroughly dry they can be packed in strong

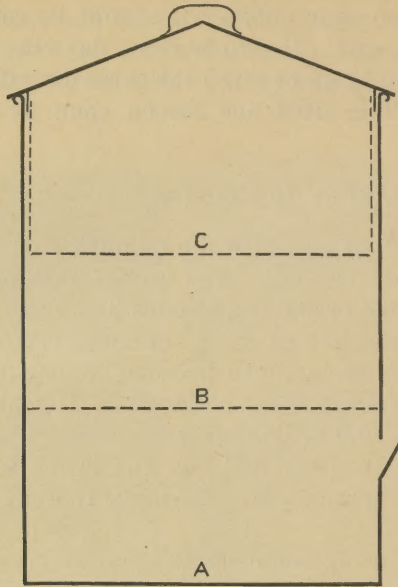


FIG. 10.—Simple stifling apparatus.

sacks and shipped to the filature. It is not necessary to pack dry cocoons in boxes which form the great proportion of the weight of the packages and greatly increase the cost of transportation. Burlaps, such as used in packing furniture, will protect dry cocoons sufficiently for long journeys by freight trains.

